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AUTHOR McKenzie, Danny L.; Karnau, Sally A.
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ABSTRACT

The effects of computer-based diagnostic testing on the laboratory achievement of 91 preservice elementary teachers were assessed. These teachers were enrolled in one of four laboratory sections of a general science course. Intact classes were randomly assigned to one of two treatment groups. All students completed the same laboratory activities during a 7-week period. Students in group one (diagnostic group) were then provided with access to a 22-item, multiple-choice, computer-based diagnostic test. Upon completion of the test, a summary of the subjects' performance on various course objectives was provided. Students in group two (non-diagnostic) did not have access to the diagnostic test. Following treatment, all subjects took a teacher-made laboratory examination. Subjects in the diagnostic group also completed an instrument to determine their attitudes toward the usefulness of the diagnostic test. Results indicate that students in the diagnostic group did not perform significantly better than students in the non-diagnostic group on the achievement test. Approximately one-half of the subjects in the diagnostic group reported that the test could be improved by providing answers to the questions that they missed. Results of the attitude survey suggest that students believe the diagnostic test was helpful in preparing for the laboratory examination. (Author/JN)

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Effects of Computer-Based Diagnostic Instruction and Non-Diagnostic Instruction on Laboratory Achievement in General Science

Danny L. McKenzie
University of South Carolina
Columbia, South Carolina 29208

Sally A. Karnau
Southwest Texas State University
San Marcos, Texas 78666

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Introduction

Diagnostic instruction involves the assessment of student progress prior to summative evaluation. This approach to teaching allows students to involve themselves in remedial activities designed to facilitate mastery in the particular skill area.

Several recent studies have examined the effects of diagnostic instruction on student achievement. Yeany, Waugh and Blalock (1979) compared the effects of two types of instruction on the achievement of preservice elementary teachers. Two groups of students received instruction on two units of biology. One group was provided with unit objectives and diagnosis while the other group received only objectives. No difference in achievement was noted on the first unit, however, the objective-diagnosis group displayed significantly higher achievement on the second unit of study. It was suggested that students may not become immediately aware of the function and proper use of feedback from the diagnostic tests.

In a related study conducted by Saunders-Harris and Yeany (1981) diagnostic and diagnostic prescriptive instruction were used with 800 middle school science students. Data was collected on the students' achievement and on retention of the subject matter. It was reported that although immediate achievement was not significantly affected, those who experienced diagnostic prescriptive instruction showed greater retention over a one month period of time.

In their meta-analysis of diagnostic remedial instruction Yeany and Miller (1982) conclude:

> On the basis of the available research findings, it appears that achievement can be significantly and positively influenced through diagnostic remedial instruction. The magnitude of this influence can be expected to be about .55 standard deviation units of achievement when compared to an instructional strategy which does not employ diagnosis and remediation. The surprising result of this study is the source of its impact. It does not appear to be remediation but rather the diagnostic feedback (p. 24).

If, as Yeany and Miller suggest, it is primarily the diagnostic feedback that is responsible for the positive influence on achievement, then it appears that the additional time spent on remediation is of little consequence.

The microcomputer provides an excellent mode of presentation for diagnostic tests. Students completing microcomputer-based diagnostic tests may receive immediate feedback regarding their performance on unit objectives. Okey and McGarity (1982) note that the microcomputer can also "relieve teachers of much of the burden of routine classroom testing" (p. 571). Therefore, it is evident that the microcomputer has the potential of being a very valuable diagnostic tool.

The purpose of the present study was to assess the effect of computer-based diagnostic testing on achievement in the laboratory portion of a college-level science course.

Methods and Data Sources

Ninety-one preservice teachers enrolled in four lab sections of a general science course were available for study. Intact classes

were randomly assigned to one of two treatment groups. Only one instructor was employed in the study. All but one of the subjects were female and all were of junior or senior standing. Using Campbell and Stanley (1966) notation the design is as follows:

$$\begin{array}{c} O_1 \; X_1 \; O_2 \; O_3 \\ \hline O_1 \; X_2 \; O_2 \end{array}$$ where

O_1 = Group Assessment of Logical Thinking (GALT) (Roadranka, Yeany & Padilla, 1983)

O_2 = Laboratory Exam

O_3 = Attitude Survey

and X_1, X_2 = Two treatment levels.

Students in each treatment group were administered the Group Assessment of Logical Thinking (GALT) (Roadranka, et al., 1983) prior to treatment. GALT is a multiple choice format, pencil and paper test requiring approximately 30 minutes to complete. The test contains items designed to measure abilities such as conservation of matter and length, combinatorial reasoning and probabilistic reasoning. The test contains 12 items; therefore, a student's score may range from 0 to 12 correct. The test developers report a reliability estimate of .85 (Cronbach's α) for GALT. Validity is demonstrated by a correlation of .80 between GALT and traditional Piagetian interview tasks. The reliability estimates for GALT (Cronbach's α) was .58 based on scores from this study.

Following pretesting all subjects were given course objectives (see Figure 1). Subjects then attended seven laboratory sessions each lasting two hours. These sessions provided activity-based experiences designed to facilitate mastery of course objectives. Following completion of the laboratory sessions, subjects in treatment group one (diagnostic group) were provided access to a 22 item, multiple choice, computer-based diagnostic test. The diagnostic test was written using TEST PAC (Okey & McGarity, 1982). The TEST PAC program was developed to aid teachers in producing interactive tests. Subjects were required to complete the diagnostic test outside of class time and were given two weeks to perform this task. Upon completion of the diagnostic test a summary was provided which listed the subjects' performance on the various objectives. Therefore, subjects were able to diagnose their own deficiencies in the lab portion of the course.

Subject in treatment group two (non-diagnostic) did not receive diagnostic testing. They did, however, complete the same lab activities as subjects in treatment group one.

Following treatment all subjects were administered a teacher-made lab examination. This test consisted of 40 multiple choice items keyed to specific course objectives. Two sample items are included as Figure 2. The reliability estimate for the laboratory examination (Cronbach's α) was .79 based on scores from this study. In addition, those subjects in treatment group one (diagnostic group) completed a brief attitude survey (Figure 3) designed to assess the

perceived usefulness of the diagnostic test.

Results and Discussion

The diagnostic group displayed a mean score of 30.63 (SD = 5.09) on the laboratory examination while the non-diagnostic group had a mean score of 29.69 (SD = 5.01) (see Table 1). Analysis of covariance procedures, with logical reasoning ability included as the concomitant variable, revealed the difference in achievement between the two groups not to be statistically significant (Table 2). A correlation of .46 (Pearson r) ($p < .001$) was noted between scores on GALT and the laboratory examination.

Results from this study indicate that students provided with diagnostic instruction did not perform significantly better than the contrast group on the dependent measure. Perhaps the lack of achievement difference can be attributed to the format of the diagnostic test. The test did not provide students with immediate feedback concerning their performance on each item, but only with a summary after completing the entire test. Approximately one half of those subjects taking the diagnostic test reported the test could be improved by providing answers to the questions that they missed. It is possible that student achievement would have been higher if immediate feedback had been provided.

Results of the attitude survey suggests that those students completing the diagnostic test believed it to be helpful in preparing for the laboratory exam (Figure 3). In addition, subjects report they feel the testing procedure should be a regular part of

the course. It is interesting to note that only 52% of the subjects reported they had used a microcomputer before taking the course and only 19% reported being exposed to diagnostic testing. This is alarming when one considers the increased use of microcomputers in kindergarten through middle school, the levels at which these future teachers will be employed.

It is not surprising to find a significant correlation between scores on GALT and the posttest laboratory examination. Many of the concepts encountered in the laboratory (e.g., density, percent weight change, latent heat of vaporization) have abstract components and require use of the reasoning modes measured by GALT. It appears, therefore, that mastery of the laboratory portion of general science may depend, in part, on one's level of formal thinking.

The present study suggests that the use of computer-based diagnostic instruction does not enhance achievement in general science laboratory. However, the diagnostic group displayed higher achievement, although not statistically higher, than the contrast group. This, coupled with the perceived value of the test suggest the need to continue to investigate the use of computer-based diagnostic tests.

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Table 1

Means Across Treatments for GALT and the Laboratory Exam

	Measure			
	Laboratory Exam		GALT	
Treatment	$\bar{X}$	SD	$\bar{X}$	SD
Diagnostic (n=38)	30.63	5.09	6.53	2.01
Non-Diagnostic (n=53)	29.69	5.01	6.25	2.31
Total (n=91)	30.08	5.04	6.36	2.18

Table 2

Analysis of Covariance Summary Table for Lab Achievement with Logical Reasoning Ability Included as a Concomitant Variable

Source of Variation	d.f	mean square	F	p
Logical Reasoning Ability (GALT)	1	478.51	23.58	.001
Treatment	1	9.01	.442	.51
Error	88	20.38		

GS 3310 OBJECTIVES Instructor: Karnau

Upon completion of labs 1-5 the student should be able to:

1. Identify the metric base units of mass, volume, and length.
2. Make simple conversions among metric units.
3. Compute the density of an unknown substance when given volume and mass values.
4. List and give definitions of various intensive physical properties (such as malleability and ductility).
5. List and give definitions of various extensive physical properties (such as weight and volume).
6. Distinguish among solids, liquids and gases.
7. Distinguish between latent heat of fusion and latent heat of vaporization.
8. Define melting point, freezing point and boiling point.
9. Identify the regions of a graph that correspond to the solid, liquid, and gaseous phases of a substance.
10. Distinguish between and give examples of chemical and physical changes.
11. Determine % weight change of a substance undergoing a chemical reaction; given the initial and final mass of the substance.
12. Distinguish between exothermic and endothermic reactions and give examples of each.
13. Describe the trends in reactivity for metals and non-metals.
14. Distinguish between groups and periods on the periodic chart.
15. Define and give an example of a binary compound.
16. Distinguish between a mineral and a rock.
17. Define and recognize the various physical properties of minerals, such as luster, hardness, streak, cleavage, and fracture.
18. Identify an unknown mineral using an identification key.
19. Define igneous, sedimentary, and metamorphic rock groups.
20. Identify the texture of a rock, and give an example of a rock with each of the following textures:
    A. glassy
    B. granular
    C. compact, dull, or stony
    D. fragmental
21. Identify an unknown rock using an identification key.
22. Recognize a rock as being of igneous, sedimentary, or metamorphic origin.

Figure 1. Objectives for the laboratory portion of General Science 3310.

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What is the percent weight change of a sample with an initial weight of 42 grams and a final weight of 63 grams?

a) .50 b) -33 c) -50 d) 50

Which one of the following rocks has a glassy texture?

a) conglomerate b) gneiss c) obsidian d) shale

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Figure 2. Sample items from the laboratory examination.

Part I.

Read the following statements and then circle the term that best describes how you feel about the statement.

(SD) = STRONGLY DISAGREE (D) = DISAGREE (N) = NEUTRAL (A) = AGREE (SA) = STRONGLY AGREE

	1	2	3	4	5	
1. I found the diagnostic tests helped me prepare for the lab exam.	(SD)	(D)	(N)	(A)	(SA)	(4.1)
2. I think the testing should become a regular part of the course.	(SD)	(D)	(N)	(A)	(SA)	(4.0)
3. I think the diagnostic tests should be mandatory.	(SD)	(D)	(N)	(A)	(SA)	(2.5)
4. I would consider using diagnostic testing in my own classroom.	(SD)	(D)	(N)	(A)	(SA)	(3.9)

Part II.

Please answer the following questions by circling the appropriate response.

1. Have you ever worked with computers before taking this course? 52% yes 48% no
2. Have you ever taken diagnostic tests as part of a course before? 19% yes 81% no
3. If the answer to question two is yes, was the diagnostic test computer based? 12% yes 88% no
4. At which location did you take the diagnostic test? 13% lab 87% library

Part III.

How could the diagnostic tests be improved?

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Figure 3. Attitude survey. Results of Part I are found at the far right in parentheses. Results of Part II are found directly above the responses.